SECTION 6

KANSAS CITY, MISSOURI, WATER DEPARTMENT

The Kansas City, Missouri, Water Department provides treated water to citizens and industry located in Kansas City. The retail service area of the Kansas City Water Department served approximately 515,000 people in 1973. Population trends in the area have shown a relatively slow increase during the past 10 years. Most of the increase in residential population has been in fringe areas of the city. Some basic facts about the system are shown in Table 24.

WATER SUPPLY SERVICE AREA

The Kansas City Water Department provides water on a retail basis to all classes of customers within the service area (Figure 10). This treated water is supplied primarily to all users within the incorporated limits of Kansas City. In addition to these areas, water is sold to other water utilities such as the Raytown Water Company, Lee Summit, Belton, and other water distributors servicing areas outside of Kansas City.

ORGANIZATION

The Kansas City Water Department operates as a department of the Kansas City government. Basically, the department provides only the service of delivering potable water to its users; however, the director of the water supply department and the director of the pollution control department (which includes sewage treatment) report to the same person. Some mixing of activities therefore occurred and had to be separated to identify costs associated with water production.

Some reorganization of the management structure occurred in the 2 years before the study began. The present organization shown in Figure 11 is made up of five divisions that report to the Director for Water Supply.

ACQUISITION

Raw water comes primarily from the Missouri River and is delivered directly to a treatment plant near the intake where all raw water is treated. A well field capable of producing 25 MGD is located near the intake facility and provides some of the raw water for the Kansas City system. The purpose of the well water, however, is primarily to assist in treatment processes and temperature control during the winter. An adequate amount of raw water

TABLE 24. KANSAS CITY, MISSOURI, WATER DEPARTMENT, BASIC FACTS*

Item	Amount
Population (1973):	
SMSA	1,295,000
County	813,900
Retail service area	515,000
Area of retail service area (sq miles)	316
Recognized customer classes (No. of accounts):	
Industrial and commercial	13,719
Residential	116,417
Suburban	1,429
Flat-rate customers	None
Percent metered	100%
Purchased water	None
Source water	10% Well - 90% River
Pipe in system (miles)	1,912.1
Elevation of treatment plant (ft above mean sea level)	754
Elevation of service area (min-max, ft)	72211188
Revenue-producing water (mil gal)	26,856
Treated water (pumpage from treatment plants, mil gal)	35,150
Max day/max hour (July 4, 1974, MGD)	179/238

* All data except population are for 1974.

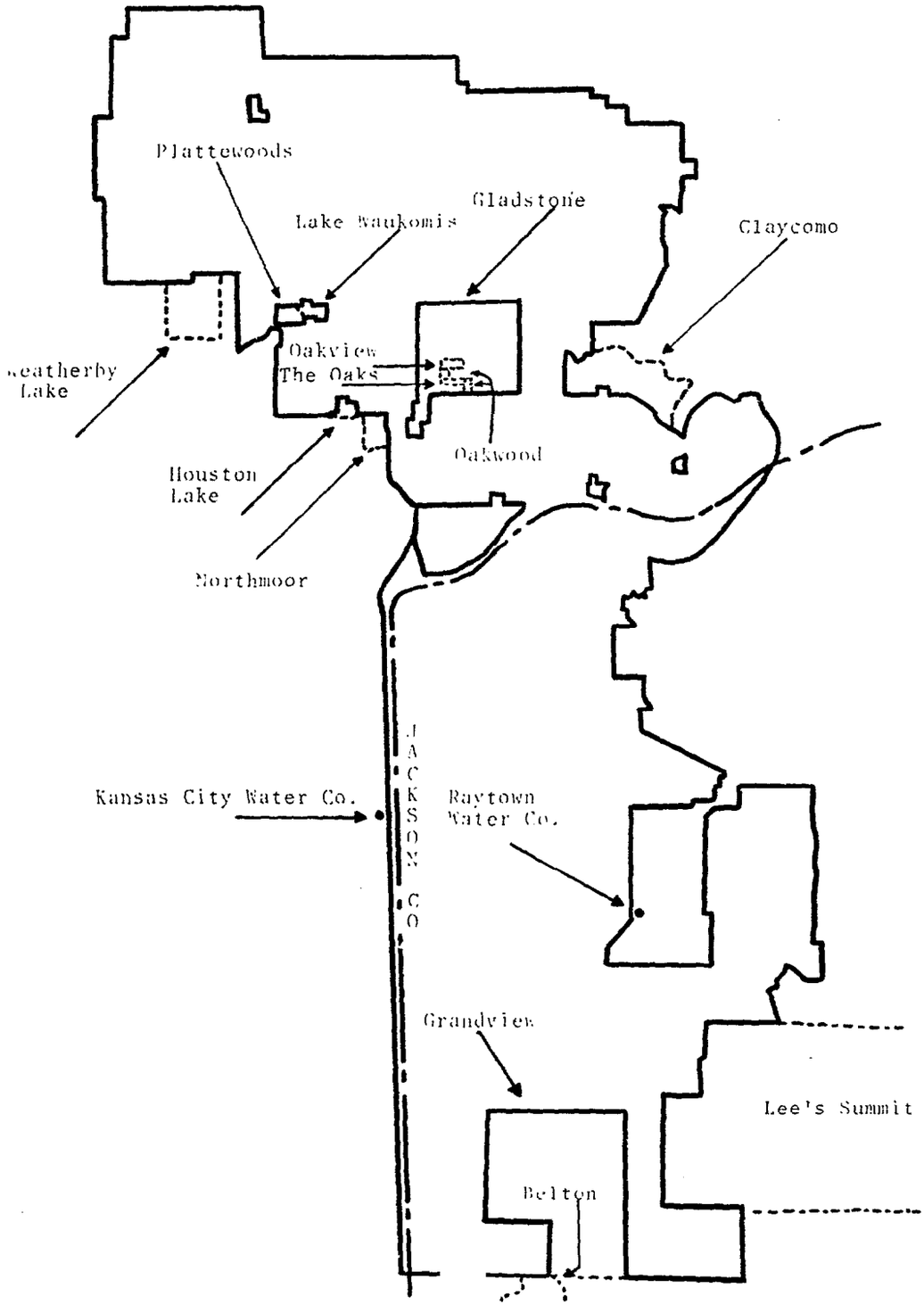


Figure 10. Kansas City water supply service area.

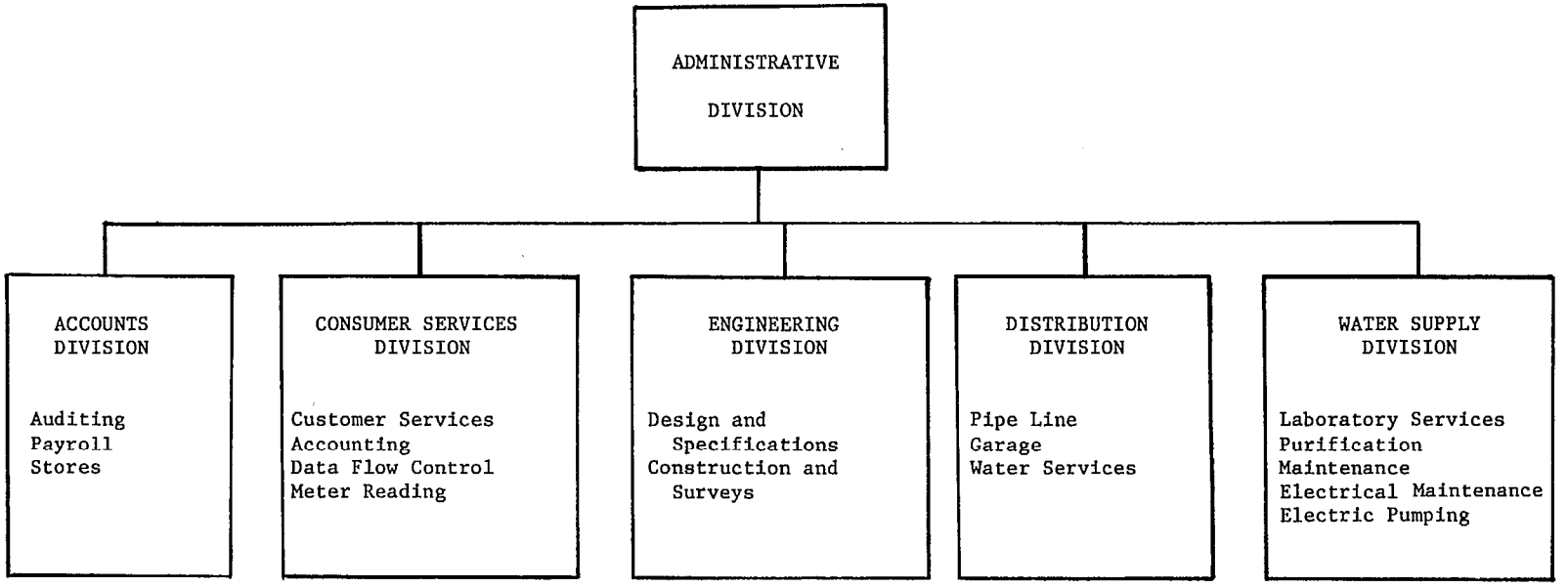


Figure 11. Kansas City Water Department organizational structure.

intake facility near the entrance to the treatment plant delivers water directly from the river to the treatment facility.

TREATMENT

All raw water for Kansas City is treated in one facility located on the bank of the Missouri River. The present plant was constructed during the mid-twenties and put into use in 1928 with a pumping capacity of 100 MGD. A vast expansion program, started in the early fifties and completed in 1958, increased the rated capacity of the plant to its present 210 MGD.

Though the plant is housed in a single facility, there are actually three separate treatment facilities, each capable of functioning independently. The treatment plant performs four primary functions: softening, sterilization, taste and odor control, and coagulation. The water goes through five stages during the treatment process: four basins and a set of filters. Chemicals are added before and after each of these stages (Figure 12).

Physical, chemical, and bacteriological characteristics of the raw water from the Missouri River vary greatly on a daily and seasonal basis, depending on numerous factors such as rainfall, temperature, flow rates, and the character of waste material discharged into the river upstream. Daily tests are made of raw water samples, and the treatment process is modified as needed for changing conditions. Tests are made on finished water samples to assure that the objectives of the treatment process are met at all times. When the water leaves the filter basin, it goes into a large underground clear well with a capacity of 7 mil gal and is ready to be moved into the transmission and distribution system, which has much greater storage capacity.

TRANSMISSION AND DISTRIBUTION

The distribution system consists of approximately 1,912 miles of pipe in the ground, ranging from the 96-in. mains leading from the treatment facility to the 2-in. mains used for distribution to homes.

The terrain served elevations ranging from 722 to 1,188 ft above sea level; therefore, it is not necessary to boost water to high elevations. But it is necessary to transmit the water over considerable distances from the one treatment plant. Transmission is accomplished by both high- and low-head pumps. To the north and west of the water plant, water is transmitted by high pressure pumps feeding directly into the distribution system and delivering water under pressure to the consumers. The Waukomis pumping station boosts the pressure and flow of water in the extreme northern portion of the delivery system. This station boosts less than 2% of the water used by consumers.

Pumping to the south is through a low pressure flow line that delivers water to a 35-mil gal ground storage reservoir at Turkey Creek and into a 17-mil gal ground storage reservoir at East Bottoms. Both of these storage

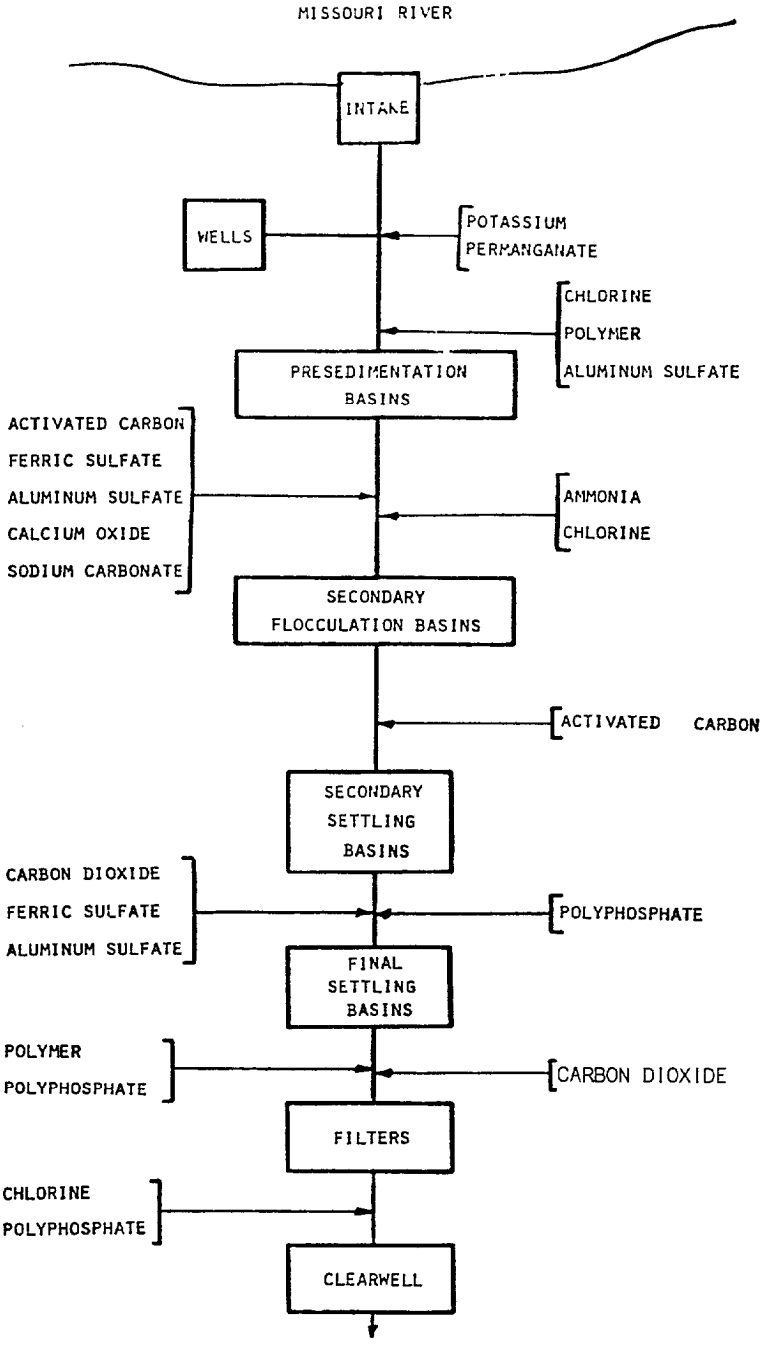


Figure 12. Kansas City Water Department treatment plant schematic.

facilities have high pressure pumps that move the water into the transmission and distribution system. Approximately 65% of the water consumed by customers is delivered directly by these two pumping stations, which also delivers water to two ground storage reservoirs located further south in the system at Waldo and Blue Ridge. Each of these reservoirs has a storage capacity of 10 mil gal and a pumping station that delivers the water under pressure into the distributions system at the southern limits of the service area. Table 25 shows the storage capacity, both ground and elevated, within the Kansas City system. As shown, there are approximately 3 mil gal of elevated storage throughout the entire system. This elevated storage assists in maintaining pressure within the distribution system but the main source of pressure comes directly from the pumps.

COST ANALYSIS

Figure 13 illustrates the growth in consumer demand for water from 1964 through 1974. A wide discrepancy exists between the amount of water treated and the amount billed. This problem was being analyzed by the water department at the time the data were gathered, and part of the difference (RFW for 1973 and 1974) then appeared to be the result of a computer problem.

Data were collected and reported using standard cost categories, as shown in Tables 26 through 28. Because a major portion of the operating budget was expended for labor, Table 29 was developed to examine costs associated with the operation and maintenance activities of the department.

The cost/man-hour increased over the 10-year period by 98%, whereas the total payroll hours required to produce a billion gallons of RPW decreased by 9% (Table 29). Thus the operating costs for producing water did not increase as rapidly as the labor cost/man-hour. However, when it is no longer possible to gain increased efficiencies with respect to manpower, the operating costs will start to increase at a rate that is at least equal to the labor cost.

Operating and capital costs for the 10-year period of the analysis are summarized in Table 30.

Capital and operating expense ratios (Table 31) provide a comparison of expenditures made for operations and capital in each of the 10 years under study. The operating expenses shown as a total value in the table are the expenses incurred in the normal day-to-day operation of the system. The capital expenses represent the total periodic expenditures for major equipment items and facilities plus the interest charged on money borrowed for that purpose.

A comparison of the operating and capital expenses as a percent of the total shows that in the Kansas City Water Department, more expenses are associated with operations than with capital. Over the 10-year period, this trend has continued and is primarily a result of the continued increase in the cost of items necessary for operation, such as increasing salaries. During the same time period, no major capital costs were incurred; therefore, the expenditure ratio shifted from 69% operating:31% capital in

TABLE 25. KANSAS CITY WATER DEPARTMENT SYSTEMS STORAGE

Type of storage	Overflow elevation (ft above sea level datum)	Capacity (mil gal)
Elevated storage tanks:		
KC1	1174	.25
North (out of service)	1124	.15
North (out of service)	1124	.15
East	1120	2.00
Ruskin	1189	.40
150 Highway	1152	.06
House service	958	.07
Total elevated storages	---	3.08

	Ground level elevation (ft above sea level datum)	Capacity (mil gal)
Ground storage reservoirs:		
Clear Well	754	7
Turkey Creek	764	35
East Bottoms	752	17
Waldo	1008	10
Blue Ridge	1019	10
Total ground storage	---	79

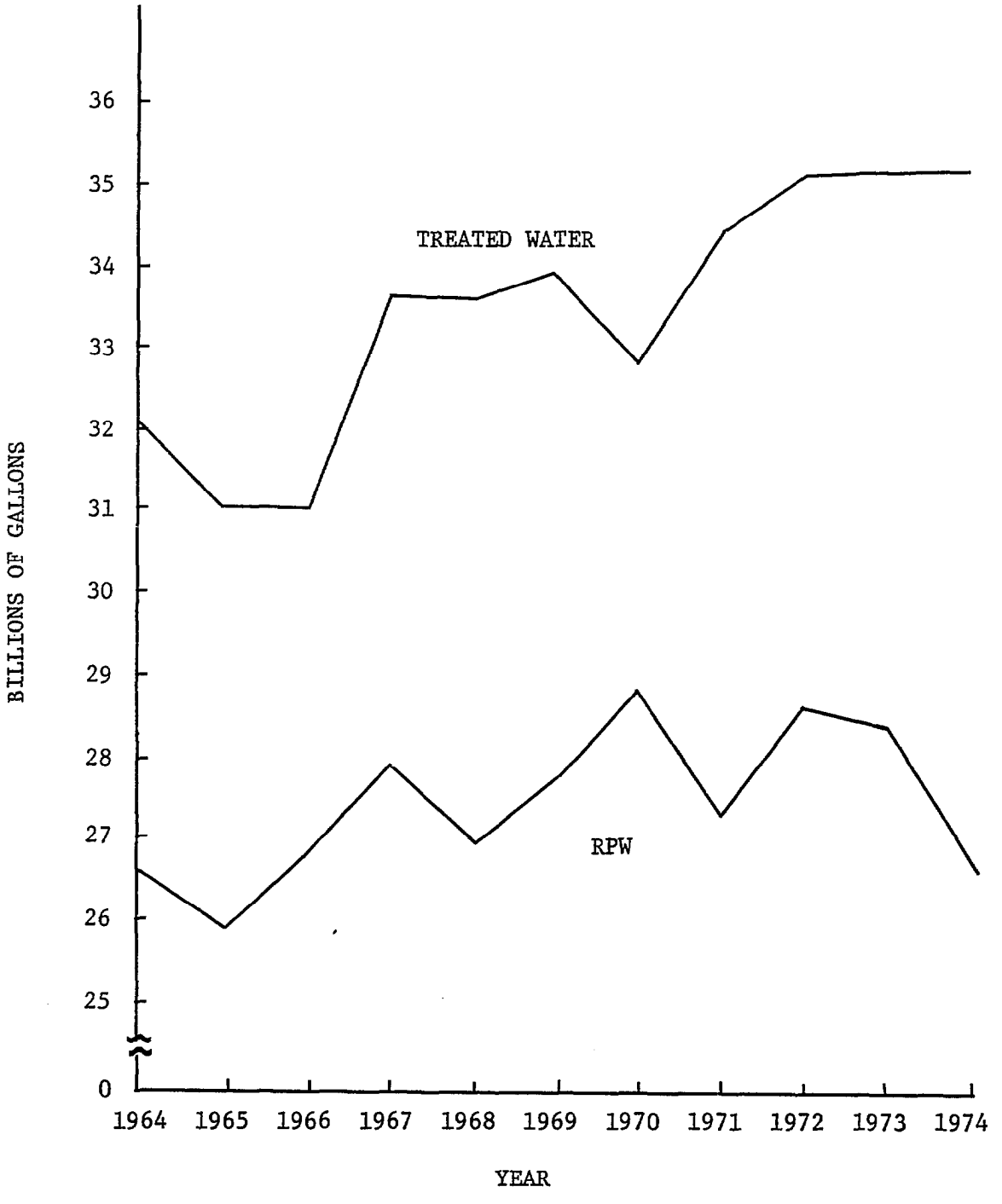


Figure 13. Kansas City water flow: treated water versus RPW.

TABLE 26. KANSAS CITY WATER DEPARTMENT ANNUAL OPERATING COSTS

Category	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
Support services:										
Administration	$ 777,760	$ 892,396	$ 860,750	$ 953,346	$1,243,758	$1,308,126	$1,518,099	$1,477,868	$1,597,632	$1,609,870
Accounting and collection	628,155	738,702	802,054	1,128,566	1,250,998	1,467,475	1,390,970	1,347,694	1,445,082	1,410,436
Service	278,532	332,123	369,497	434,332	484,127	486,498	549,484	523,104	543,821	544,270
Other	152,603	99,154	112,638	134,914	169,385	155,301	107,146	231,287	228,826	221,808
Total support services	1,837,050	2,062,375	2,144,939	2,651,158	3,148,268	3,417,400	3,565,699	3,579,953	3,815,361	3,786,384
Acquisition:										
Operating labor	33,818	41,574	43,192	51,824	59,821	63,369	65,459	57,068	71,119	76,485
Maintenance	11,997	6,519	11,315	25,322	32,981	26,332	31,330	34,164	36.749	28,677
Power	152,703	146,082	159,578	159,099	168,077	168,537	179,968	199,767	200,370	216,147
Other	34,162	36,244	36,683	40,843	45,861	59,734	60,311	59,210	57,124	53,068
Total acquisition	232,680	230,419	250,768	277,087	306,740	317,972	337,068	350,210	365,362	374,378
Treatment:										
Laboratory	57,755	69,717	80,672	74,728	112,268	136,431	141,653	179,765	192,829	196,290
Operating labor	125,490	139,192	134,802	173,343	181,001	190,719	176,840	185,954	220,294	228,645
Chemicals	492,523	531,327	576,501	523,917	488,972	673,105	705,175	799,833	992,883	959,156
Maintenance	157,316	139,655	166,376	192,978	222,492	180,958	168,861	180,960	202,370	262,294
Other	184,811	206,096	236,433	231,513	285,859	353,555	369,907	369,630	274,674	352,140
Total treatment	1,017,895	1,085,986	1,194,784	1,196,479	1,290,592	1,534,768	1,562,436	1,716,142	1,883,050	1,998,525
Power and pumping:										
Operating labor	138,864	170,710	177,356	212,800	245,635	260,207	268,789	234,335	292,030	314,064
Maintenance	49,264	26,768	46,461	103,975	135,428	108,125	128,647	140,284	150,889	117,756
Power	627,029	599,845	655,260	653,293	690,160	692,050	738,988	820,287	822,761	887,546
Other	140,278	148,825	150,628	167,708	188,314	245,278	247,648	243,128	234,563	217,910
Total power and pumping	955,435	946,148	1,029,706	1,137,777	1,259,537	1,305,661	1,384,072	1,438,033	1,500,253	1,537,275
Transmission and distribution:										
Operating labor	79,277	77,593	95,026	99,400	117,922	129,439	125,080	171,432	175,793	185,499
Maintenance	364,533	425,728	493,108	505,435	560,517	738,226	747,918	785,554	717,772	773,622
Other	139,731	126,140	140,908	163,829	199,586	200,004	240,385	238,750	258,166	245,815
Total transmission and distr.	583,541	629,461	729,042	768,664	878,025	1,067,669	1,113,383	1,195,736	1,151,731	1,204,936
Total operating cost	4,626,601	4,954,389	5,349,239	6,031,165	6,883,162	7,643,470	7,962,658	8,280,074	8,715,757	8,901,498

TABLE 27. KANSAS CITY WATER DEPARTMENT UNIT OPERATING COSTS ($/MIL GAL RPW)

Category	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
Support services:										
Administration	$ 29.68	$ 33.07	$ 30.67	$ 35.13	$ 44.68	$ 45.28	$ 55.34	$ 51.44	$ 56.71	$ 59.95
Accounting and collection	23,97	27.37	28.58	41.58	44.94	50.79	50.71	46.91	51.30	52.52
Service	10.63	12.31	13.17	16.00	17.39	16.84	20.03	18.21	19.30	20.27
Other	5.82	3.67	4.01	4.97	6.08	5.38	3.91	8.05	8.12	8.26
Total support services	70.11	76.43	76.43	97.68	113.10	118.28	129.98	124.60	135.44	140.99
Acquisition:										
Operating labor	1.29	1.54	1.54	1.91	2.15	2.19	2.39	1.99	2.52	2.85
Maintenante	0.46	0.24	0.40	0.93	1.18	0.91	1.14	1.19	1.30	1.07
Power	5.83	5.41	5.69	5.86	6.04	5.83	6.56	6.95	7.11	8.05
Other	1.30	1.34	1.31	1.50	1.65	2.07	2.20	2.06	2.03	1.98
Total acquisition	8.88	8.54	8.94	10.21	11.02	11.01	12.29	12.19	12.97	13.94
Treatment:										
Laboratory	2.20	2.58	2.87	2.75	4.03	4.72	5.16	6.26	6.84	7.31
Operating labor	4.79	5.16	4.80	6.39	6.50	6.60	6.45	6.47	7.82	8.51
Chemicals	18.80	19.69	20.54	19.30	17.57	23.30	25.71	27.84	35.24	35.71
Maintenance	6.00	5.18	5.93	7.11	7.99	6.26	6.16	6.30	7.18	9.77
Other	7.05	7.64	8.43	8.53	10.27	12.24	13.48	12.86	9.75	13.11
Total treatment	38.85	40.24	42.58	44.08	46.36	53.12	56.96	59.73	66.84	74.42
Power and pumping:										
Operating labor	5.30	6.33	6.32	7.84	8.82	9.01	9.80	8.16	10.37	11.69
Maintenance	1.88	0.99	1.66	3.83	4.87	3.74	4.69	4.88	5.36	4.38
Power	23.93	22.23	23.35	24.07	24.79	23.95	26.94	28.55	29.21	33.05
Other	5.35	5.52	5.37	6.18	6.76	8.49	9.03	8.46	8.33	8.11
Total power and pumping	36.46	35.06	36.69	41.92	45.25	45.19	50.45	50.05	53.26	57.24
Transmission and distribution:										
Operating labor	3.03	2.88	3.39	3.66	4.24	4.48	4.56	5.97	6.24	6.91
Maintenance	13.91	15.78	17.57	18.62	20.14	25.55	27.26	27.34	25.48	28.81
Other	5.33	4.67	5.02	6.04	7.17	6.92	8.76	8.31	9.16	9.15
Total transmission and distribution	22.27	23.33	25.98	28.32	31.54	36.95	40.59	41.62	40.88	44.87
Total operating cost	176.56	183.60	190.62	222.21	247.27	264.55	290.27	288.18	309.39	331.45

The above figures are not additive. They are obtained by dividing yearly mil gal RPW into the annual costs shown in the preceding table.

TABLE 28. KANSAS CITY WATER DEPARTMENT OPERATING COST CATEGORIES AS PERCENT OF TOTAL OPERATING COST

Category	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
Support services:										
Administration	16.81	18.01	16.09	15.81	18.07	17.11	19.07	17.84	18.33	18.09
Accounting and collection	13.58	14.91	14.99	18.71	18.17	19.20	17.47	16.28	16.57	15.84
Service	6.02	6.70	6.91	7.20	7.03	6.36	6.90	6.32	6.24	6.11
Other	3.30	2.00	2.11	2.24	2.46	2.03	1.35	2.79	2.63	2.49
Total overhead	39.71	41.62	40.10	43.96	45.74	44.71	44.79	43.23	43.77	42.54
Acquisition:										
Operating labor	0.73	0.84	0.81	0.86	0.87	0.83	0.82	0.69	0.82	0.86
Maintenance	0.26	0.13	0.21	0.42	0.48	0.34	0.39	0.41	0.42	0.32
Power	3.30	2.95	2.98	2.64	2.44	2.20	2.26	2.41	2.30	2.43
Other	0.74	0.73	0.69	0.68	0.67	0.78	0.76	0.72	0.66	0.60
Total acquisition	5.03	4.65	4.69	4.59	4.46	4.16	4.23	4.23	4.20	4.21
Treatment:										
Laboratory	1.25	1.41	1.51	1.24	1.63	1.78	1.78	2.17	2.21	2.21
Operating labor	2.71	2.81	2.52	2.87	2.63	2.50	2.22	2.25	2.53	2.57
Chemicals	10.65	10.72	10.78	8.69	7.10	8.81	8.86	9.66	11.40	10.78
Maintenance	3.40	2.82	3.11	3.20	3.23	2.37	2.12	2.19	2.32	2.95
Other	3.99	4.16	4.42	3.84	4.15	4.63	4.65	4.46	3.15	3.96
Total treatment	22.00	21.92	22.33	19.84	18.75	20.08	19.62	20.73	21.61	22.45
Power and pumping:										
Operating labor	3.00	3.45	3.32	3.53	3.57	3.40	3.38	2.83	3.35	3.53
Maintenance	1.06	0.54	0.87	1.72	1.97	1.41	1.62	1.69	1.73	1.32
Power	13.55	12.11	12.25	10.83	10.03	9.05	9.28	9.91	9.44	9.97
Other	3.03	3.00	2.82	2.78	2.74	3.21	3.11	2.94	2.69	2.45
Total power and pumping	20.65	19.10	19.25	18.86	18.30	17.08	17.38	17.37	17.21	17.27
Transmission and distribution:										
Operating labor	1.71	1.57	1.78	1.65	1.72	1.69	1.57	2.07	2.02	2.08
Maintenance	7.88	8.59	9.22	8.38	8.14	9.66	9.39	9.49	8.23	8.69
Other	3.02	2.55	2.63	2.72	2.90	2.62	3.02	2.88	2.96	2.76
Total transmission and distribution	12.61	12.71	13.63	12.75	12.76	13.97	13.98	14.44	13.21	13.53
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

TABLE 29. KANSAS CITY WATER DEPARTMENT LABOR COST ANALYSIS

Category	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
Total payroll ($)	2,627,096	2,707,386	2,834,801	3,335,272	3,864,478	4,276,038	4,572,337	4,486,488	4,577,926	4,865,085
Total hours on payroll	1,219,867	1,206,749	1,167,368	1,276,910	1,359,372	1,371,570	1,309,498	1,153,979	1,113,292	1,143,839
RPW (mil gal)	26,204	26,985	28,063	27,141	27,837	28,892	27,432	28,732	28,171	26,856
Total payroll/mil gal ($)	100.26	100.33	101.01	122.89	138.82	148.00	166.68	156.15	162.51	181.16
Total hours/mil gal	46.55	44.72	41.60	47.05	48.83	47.47	47.74	40.16	39.52	42.59
Average cost/man-hour ($)	2.15	2.24	2.43	2.61	2.84	3.12	3.49	3.89	4.11	4.25

TABLE 30. KANSAS CITY WATER DEPARTMENT CAPITAL AND OPERATING COSTS

Item	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
Operating expense ($)	4,626,004	4,954,389	5,349,239	6,031,165	6,883,161	7,643,472	7,962,659	8,280,075	8,715,758	8,901,496
Depreciation, amortization ($)	1,008,700	1,042,635	1,055,788	1,065,576	1,098,210	1,117,895	1,156,777	1,202,328	1,263,516	1,315,193
Other (interest) ($)	1,063,760	1,067,192	981,434	939,797	1,061,401	1,207,367	1,519,028	1,456,258	1,406,804	1,351,320
Total cost ($)	6,699,064	6,507,351	7,386,461	8,036,538	9,042,772	9,968,733	10,638,464	10,938,661	11,386,078	11,568,009
Unit cost ($/mil gal RPW)	255.65	241.15	263.21	296.10	324.84	345.03	387.82	380.71	404.18	430.74

TABLE 31. KANSAS CITY WATER DEPARTMENT CAPITAL VERSUS OPERATING EXPENSES RATIOS

Item	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
Operating expense ($)	4,626,604	4,954,389	5,349,239	6,031,165	6,883,161	7,643,472	7,962,659	8,289,075	8,715,758	8,901,496
Capital expense ($)	2,072,460	2,109,827	2,037,221	2,005,373	2,159,611	2,325,261	2,675,805	2,658,586	2,670,320	2,666,513
Total expense ($)	6,699,064	7,064,216	7,386,460	8,036,538	9,042,772	9,968,733	10,638,464	10,938,661	11,386,078	11,568,009
Operating expense as % of total	69.06	70.13	72.42	75.05	76.17	76.67	74.85	75.70	76.55	76.95
Capital expense as % of total	30.94	29.87	27.58	24.95	23.83	23.33	25.15	24.30	23.45	23.05

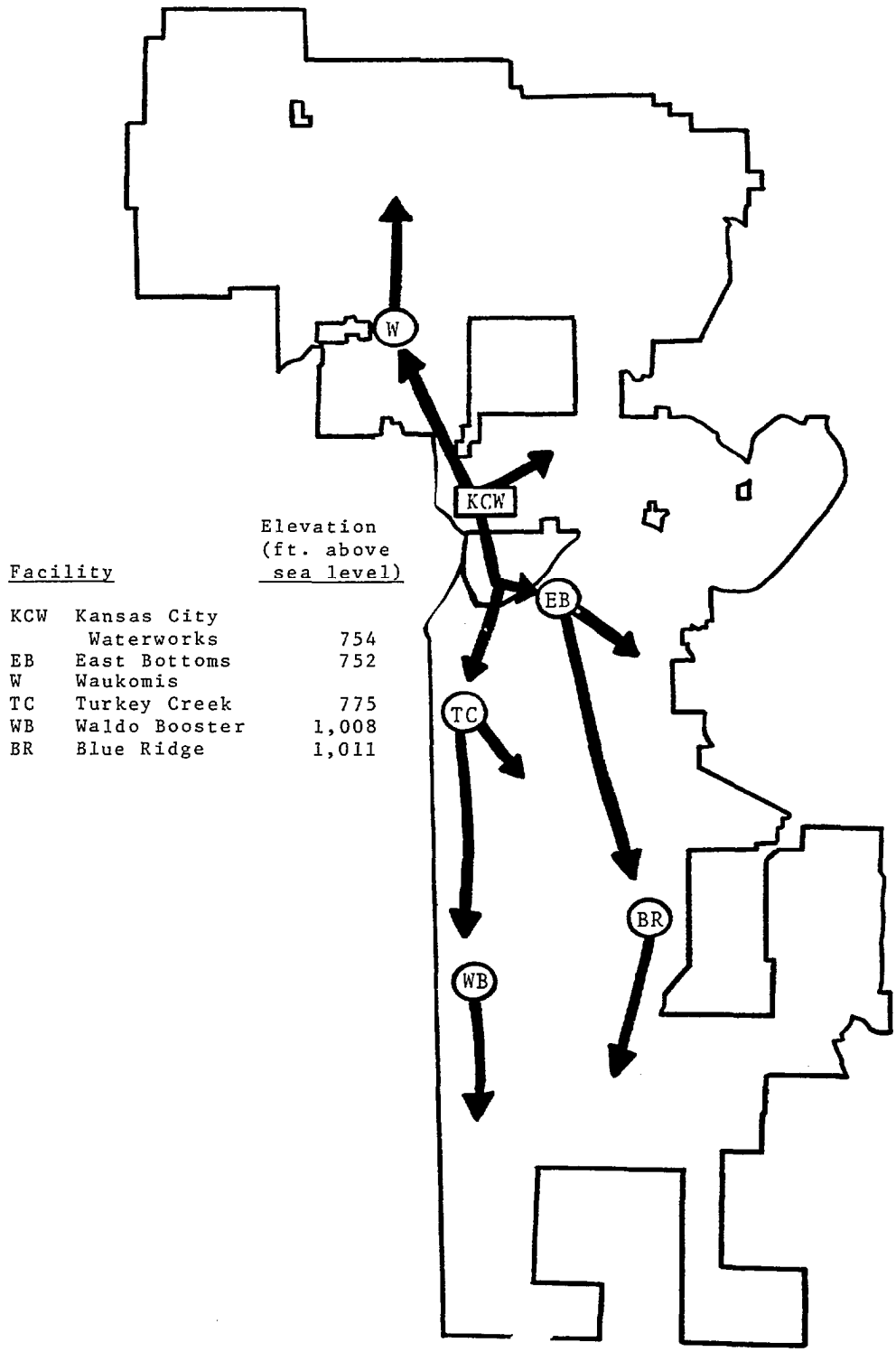
1965 to 77% operating:23% capital in 1974.

The Kansas City system is relatively old; therefore, the capital depreciated was expended when costs were significantly lower than at present. On the other hand, the operating expenses are in current dollars. This ratio will change whenever capital investments are made by the utility. For example, at some time in the future, major capital expenditures may be required at the treatment facility to meet increasing demands. When this occurs, the ratio of capital expense to operating expense will increase significantly.

SYSTEM COSTS

Examination of the costs on a functional basis is only a part of the total picture. Since the purpose of the water utility is to deliver water to customers, it is important to be able to present the costs in such a way that they relate to the delivery of water to the demand point within the distribution system. The functional categories, both operating and capital, should therefore be reaggregated and assigned to the physical components of the water delivery system. This section contains such a cost analysis of the water supply system.

To analyze the cost of water as it moves from acquisition to treatment and on to the consumer, it is necessary to identify the capital and operating costs of the system components. Figure 14 shows the location of the Kansas City Water Department facilities, and Figure 15 is a schematic diagram showing operating and capital costs for each of the major system components. A linear assumption is made that allows costs/mil gal to be added as water moves from one component of the system to another. For example, the cost of acquiring water from the Missouri River and moving it to the treatment plant is $15.28/mil gal. The cost of treating the water from the time it arrives at the treatment plant until it is pumped out is $81.98/mil gal. Two types of pumping occur out of the treatment plant: high-pressure pumping into the distribution system to the northwest, and low pressure flowline pumping to the south, toward the Turkey Creek and the East Bottoms storage and pumping facilities. Farther to the south, flowline pumping costs $16,87/mil gal, with an additional operating capital cost of the flowline amounting to $1.53. This moves the water to the pumping stations, which perform the function of high-pressure pumping into the distribution system. This high pressure pumping costs $38.41. Adding these costs together yields a total incremental cost for providing water to service Zone 3 of $163.19/mil gal (see Table 32). Added to the incremental costs are those for distribution, interest, and support services. Distribution costs are calculated on the assumption that these costs on a mil gal basis are constant throughout the system; therefore, the total capital and operating cost for distribution is divided by the number of gallons of RPW in the year under consideration, yielding a figure of $61.05/mil gal. The same approach is taken for interest and support services. When these are added together, a total cost/mil gal for water to a given zone results. For example, the total cost of water delivered to Zone 3 is $419.43/mil gal. Table 32 also contains the metered



Facility		Elevation (ft. above sea level)
KCW	Kansas City Waterworks	754
EB	East Bottoms	752
W	Waukomis	
TC	Turkey Creek	775
WB	Waldo Booster	1,008
BR	Blue Ridge	1,011

Figure 14. Kansas City Water Department facilities (arrows depict general direction of water flow).

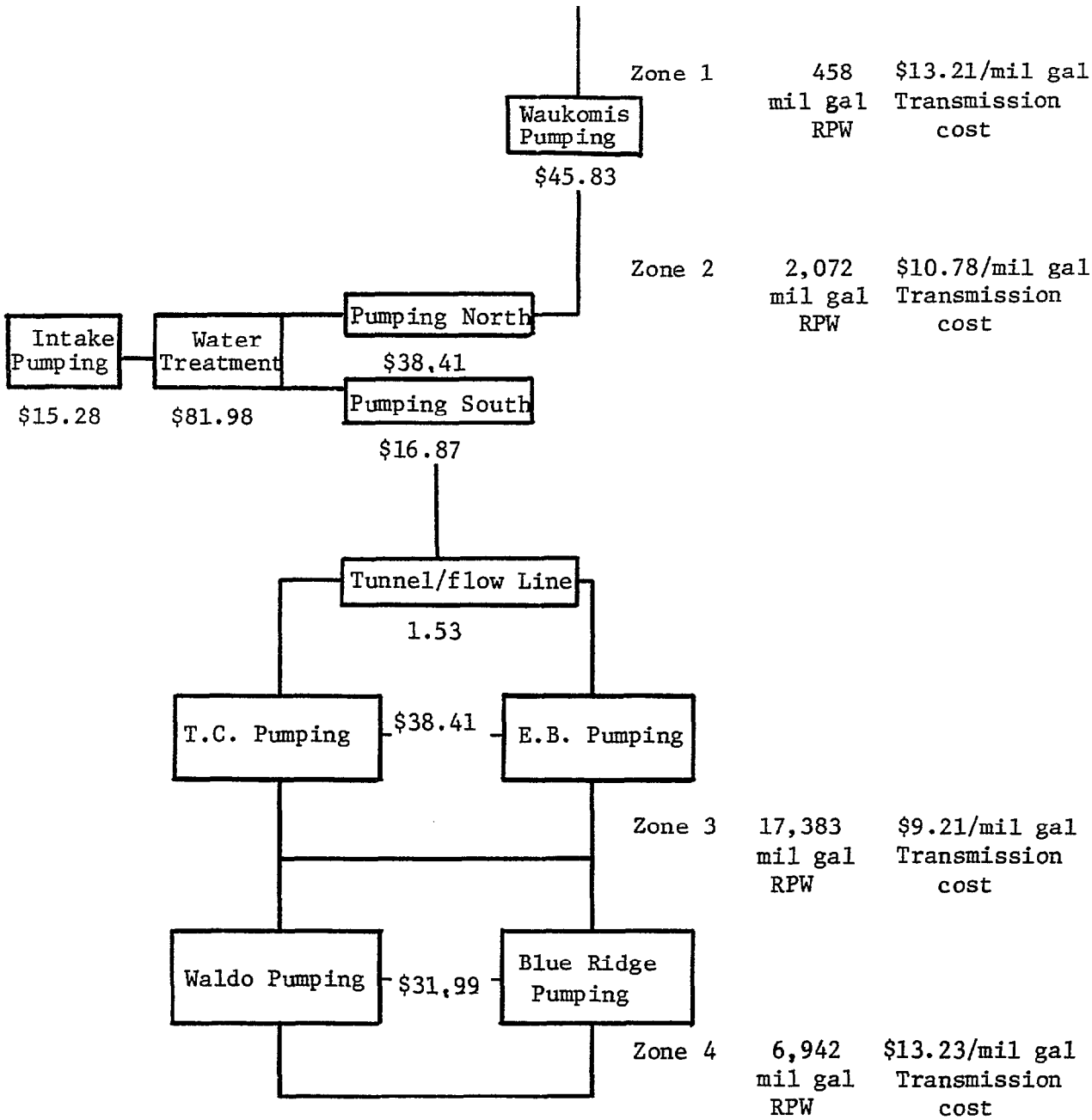


Figure 15. Kansas City Water Department allocation of capital and operating expenses to water system components ($/mil gal RPW).

TABLE 32. KANSAS CITY WATER DEPARTMENT COST, CONSUMPTION, AND REVENUE, BY ZONE

Zone	Incremental costs ($/mil gal)	Distribution costs ($/mil gal)	Interest ($/mil gal)	Support services ($/mil gal)	Total* cost (S/mil gal)	RPW (mil gal)	Revenue
1	$205.40	$61.05	$50.32	$144.52	$461.33	458	$ 211,289
2	146.36	61.05	50.32	144.52	402.25	2,072	833,462
3	163.19	61.05	50.32	144.52	419.43	17,383	7,290,952
4	208.45	61.05	50.32	144.52	464.34	6,942	3,223,448
Total	---	---	---	---	---	26,855	11,559,151

* Average cost/zone is $436.83

consumption for each of the pressure areas and the estimated contributions of revenue for recovering the total cost.

Once these calculations are made and various cost zones are established, costs versus charges can be examined. Tables 33, 34, and 35 contain the Kansas City rate schedules.

The cost of water for the 10 largest consumers of the Kansas City Water Department is broken down in Table 36.

The locations of these 10 major users within the service area are shown in Figure 16. By comparing each location with the cost allocations in Table 32, it is possible to identify the actual allocated cost of delivering water to the individual consumer. This comparison shows that in some cases the water department is recovering its cost for water, and in other cases, the charge is substantially less than the actual cost of producing and delivering the water.

Average costs for all RPW during the most recent year studied are as follows:

	$/mil gal
Support services	145
Acquisition	15
Treatment	82
Distribution	138
Interest	50
Total	430

TABLE 33. KANSAS CITY WATER DEPARTMENT METER RATES ($/mil gal)

Meter size (in.)	City rate	Suburban rate
5/8	$ 1.30	$ 2.20
3/4	1.50	2.50
1	1.85	3.30
1-½	2.50	4.50
2	3.75	6.50
3	7.50	12.50
4	12.50	22.00
6	25.00	44.00
8	37.50	66.00
10	55.00	93.00

TABLE 34. KANSAS CITY WATER DEPARTMENT COMMODITY CHARGES

Item	Amount ($/mil gal)
City:	
First 50 units @ $.39	$521.35
Next 250 units @ $.28	374.31
Next 4,700 units @ $.23	307.47
Over 5,000 units @ $.14	187.15
Suburban:	
First 20 units @ $.53	708.50
Next 480 units @ $.44	588.19
Over 500 units @ $.32	427.78

TABLE 35. KANSAS CITY WATER DEPARTMENT CHARGE ANALYSIS

Units served	Gallons used	Total charge	
		City	Suburban
13.4	10,000	$5.22	$7.01
5,000	3,740,260	1,170.56	1,661.80
100,000	74,805,200	14,470.32	32,061.80
150,000	112,207,800	21,470.22	48,061.80

TABLE 36. KANSAS CITY WATER DEPARTMENT WATER COSTS FOR 10 MAJOR USERS

Major Users	High or low month	Month	Units used (mil gal)	Amount billed	Unit Charge ($/mil gal)	Location	Cost zone
Sheffield Steel	High	5	120.6	$23,055	$191.16	City	3
	Low	3	74.7	14,435	193.21		
AEC	High	6	112.6	21,804	193.68	City	4
	Low	10	16.8	3,670	218.73		
Ford Motor Co.	High	5	53.1	22,778	428.99	Suburb	2
	Low	11	14.3	6,164	432.35		
K. C. Power & Light	High	10	46.4	9,188	198.08	City	3
	Low	3	10.2	2,389	234.62		
Raytown Water Co.	High	6	41.9	17,960	428.94	Suburb	3
	Low	1	21.1	9,063	430.42		
Union Wire & Rope	High	5	24.5	5,077	206.84	City	3
	Low	6	5.5	1,462	266.89		
J. C. Nichols	High	12	31.5	13,532	429.95	Suburb	3
	Low	4	6.0	2,645	438.42		
K. C. Stockyards	High	10	16.9	2,488	147.03	Flowline	3
	Low	9	9.8	1,442	147.09		
Lee Summit	High	12	28.1	12,087	430.20	Suburb	4
	Low	9	4.0	1,759	443.50		
Belton	High	12	37.0	15,892	429.62	Suburb	4
	Low	9	5.4	2,355	437.80		

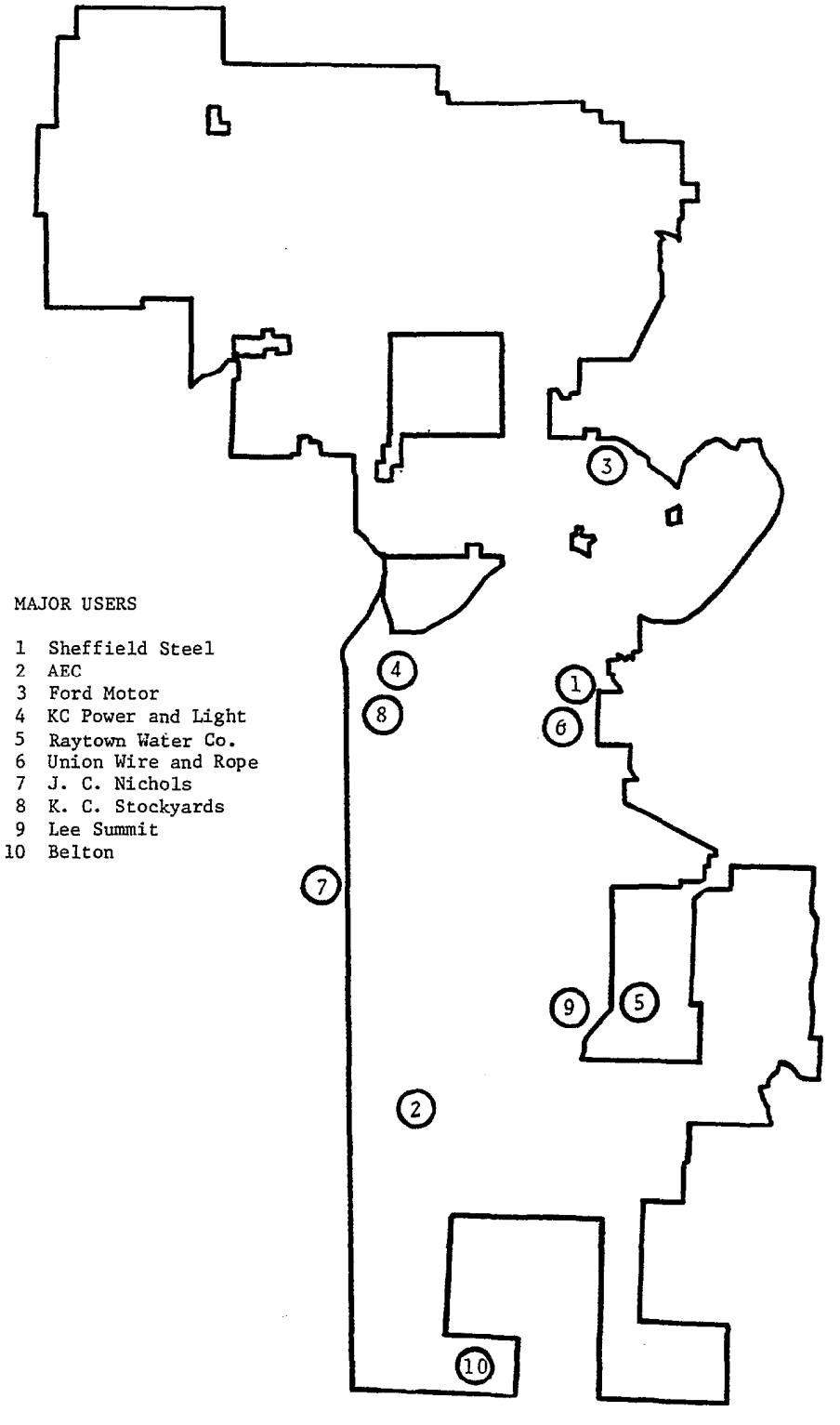


Figure 16. Locations of 10 major users within the Kansas City service area.

SECTION 7

DALLAS WATER UTILITY

The City of Dallas lies within Dallas County in north central Texas. Based on the 1970 census, the city has a population of 942,462, and the population of the county is nearly 1.6 million. The Dallas metropolitan area is growing at the rate of 3.1%/year. This growth rate has many implications for urban services such as water supply. Some system facts are shown in Table 37.

WATER SUPPLY SERVICE AREA

The Dallas Water Utility provides water on a retail basis to all classes of customers within the city's five service areas (Figure 17). Treated water is supplied to 19 cities ("county towns") within Dallas County, and also to the Dallas-Fort Worth Regional Airport. Some water is also sold to communities outside Dallas County. Service is provided to each of the cities through one or more master meters, and contracts are negotiated individually by the utility with each county town or water service area. The contracts are for 1 to 50 years, with 20- or 30-year contracts being most common, The total consumption for the customer cities and the airport in 1974 was 12,438 mil gal, approximately 20% of the total metered consumption.

The rate of increase in the population is expected to continue. A great deal of emphasis is placed on meeting the treated water needs of the Dallas county towns as they turn to the Dallas Water Utility for additional water. At present, financing and developing of new reservoirs is a primary concern for the utility.

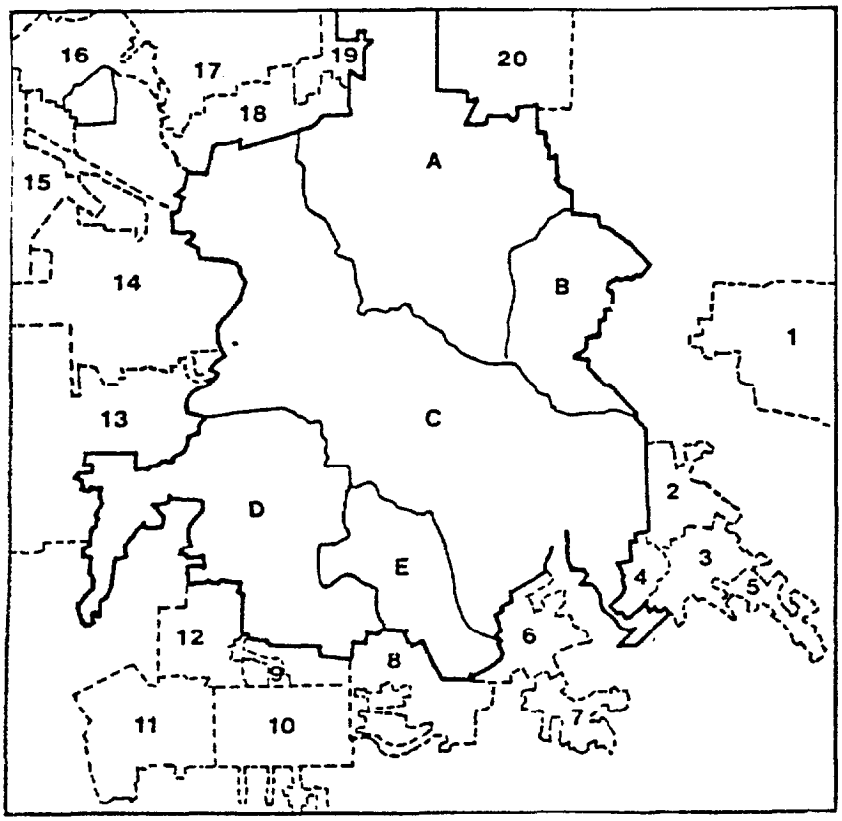
ORGANIZATION

The Dallas Water Utility combines both water supply and wastewater treatment functions. Because the accounting systems are also combined, it was necessary to estimate the costs assigned to each operation where overlap in functions occurred. The structure of the organization (Figure 18) is composed of engineering and planning, operations, and business sections.

The Engineering and Planning Section plans all system improvements, analyzes pumpage, flow, and consumption data to evaluate the adequacy of the system, and coordinates the development of long-range plans with engineering consultants. The Business Section is responsible for accounting, meter reading, billing, and collecting for the utility.

TABLE 37. DALLAS WATER UTILITY, BASIC FACTS (1974)

Item	Amount
Population:	
SMSA	2,729,356
county	1,549,221
Retail service area	942,462
Area of retail service area (sq miles)	301.38
Recognized customer classes (no. of meters)	
Residential	201,830
Commercial	20,508
Government	1,015
Apartment	5,272
Industrial	129
Suburban cities	35
Flat rate (no. accounts)	None
Percent metered	100
Purchased water (mil gal treated)	2,770
Source water	100% surface impoundment
Pipe in system (miles)	3,208
Elevation of treatment plants (ft above mean sea level):	
Bachman	446
Elm Fork	458
East Side	480
	(146)
Elevation of service area (min-max ft)	430 - 875
Revenue-producing water (mil gal)	63,030
Treated water (pumpage from treatment plants + treated purchased water, mil gal)	70,656
Maximum day/maximum hour (MGD)	433/665



CUSTOMER CITIES OUTSIDE DALLAS

1 Sunnyvale
2 Balch Springs
3 Kleberg
4 Rylie
5 Seagoville
6 Hutchins
7 Wilmer
8 Lancaster
9 Woodland Hills
10 DeSoto
11 Cedar Hill
12 Duncanville
13 Grand Prairie
14 Irving
15 Regional Airport
16 Coppell
17 Carrollton
18 Farmers Branch
19 Addison
20 Richardson

CITY OF DALLAS SERVICE AREAS

A North High
B East High
C Central Low
D South High
E Trinity Heights - Cedardale Intermediate

Figure 17. Dallas Water Utility water supply service area.

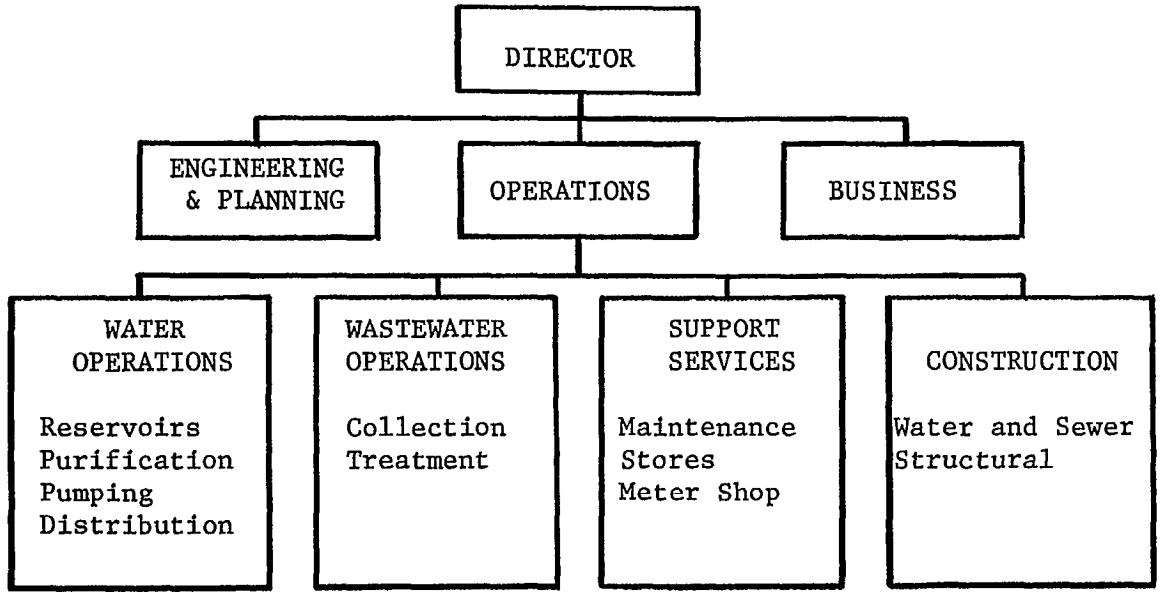


Figure 18. Dallas Water Utility organizational structure.

The Water Operations Division is the largest of the four divisions within the Operations Sections. All water production and distribution functions are handled by this division. The Wastewater Operations Division is responsible for the collection and treatment of wastewater. The Support Services Division maintains equipment and meters and is responsible for storage of spare parts. The Construction Division supervises the installation of additions to the system.

All three sections handle both wastewater and water supply responsibilities through the division level. The only division handling water supply is the Water Operations Division. Separate costs are maintained for both water and wastewater activities by the business section.

ACQUISITION

Raw water comes from five major reservoirs and is treated in treatment plants located in the northwest, central, and southeast sections of the city. The treatment plants are generally located in the low-lying areas, thus requiring that water be pumped up to residences and businesses located at higher elevations.

Dallas paid $5.5 million toward the cost of dams to be built at Lewisville on the Elm Fork of the Trinity River and at Grapevine on Denton Creek. The remaining construction cost for the dams was paid by the Federal government. In return the Federal government reserved 163 billion gallons of water in the Garza-Little Elm and Grapevine reservoirs exclusively for Dallas' use.

Lavon reservoir is operated by the North Texas Municipal Water District. Under the terms of a contract, Dallas will be provided until 1991 with an average of 10 MGD of treated water, which is furnished to the northeast section of the city at the Casa View station.

Lake Ray Hubbard on the East Fork of the Trinity River has a capacity of 181 billion gallons. It was built for water supply only and is owned entirely by Dallas.

Lake Tawakoni is located on the Sabine River and lies in an entirely different watershed from Dallas. The reservoir and dam were built by Dallas and the U.S. Corps of Engineers and turned over to the Sabine River Authority in return for 80% of the water yield. The lake normally holds 306 billion gallons.

Waters from the Garza-Little Elm and Grapevine reservoirs flow in natural channels to points near the Bachman and Elm Fork treatment plants. At these plants, the raw water is removed from the channel by pumps located in the treatment facility.

Water from Lake Hubbard is pumped directly to the East Side treatment plant by a remote pump station controlled by the treatment plant.

Water from Lake Tawakoni is pumped 18 miles through a 60-in. pipeline to a 266-mil gal interim reservoir located on the ridge separating the Sabine and East Fork watersheds. The water then flows by gravity to the East Side treatment plant.

TREATMENT

Raw water is treated at Elm Fork, Bachman, and East Side. Each facility was constructed at a different time in response to increasing demands.

The Elm Fork treatment plant, completed in 1952, is about 4 miles northwest of the city and has a capacity of 196 MGD. It is equipped with activated carbon facilities in addition to chlorinators, primary and secondary flocculators, and settling tanks. It also houses a 13.2-mil gal clear well storage facility. Onsite pumping facilities include five 30-MGD at 58 feet of head, low-service pumps, four 30-MGD and one 15-MGD at 280 feet discharge head, high-service pumps, plus additional wash-water pumps. The high-service pumps put water directly into the distribution system.

The Bachman purification plant, located within the city limits, was completed in 1930 and has a capacity of 116 MGD. Its design is similar to that of Elm Fork, but it has no secondary flocculators. The plant has four centrifugal water pumps, 14 high-service pumps, and one wash-water pump. The clear wells at Bachman have a total capacity of 20 mil gal, and the high-service pumps put water directly into the distribution system.

The East Side treatment plant, about 5 miles east of the city, was completed in 1964. Its design capacity is 205 MGD, and it has flocculators, primary clarifiers, secondary settling basins, and filters. There are no low-service pumps located at the plant because water flows from the interim reservoir by gravity.

In the chemical treatment processes, seven chemicals are fed into the plants in proportion to the amount of water treated, but the quality of the raw water determines the specific amount of each chemical used. The chemicals used, their purpose, and the order of application are as follows:

1. Activated carbon is used to absorb organic matter and to control taste and odor.

2. Chlorine is added in the initial phases of treatment to start the process of killing bacteria, to prevent the growth of algae in the basins, and to oxidize organic matter.

3. Lime serves as a softening agent, combines with other chemicals to settle out suspended matter, and adjusts the alkalinity of the water to make it less corrosive.

4. Ferric sulfate is the chief clarifying agent. It combines with part of the lime.

5. Fluosilicic acid is the flouridating agent and is added at the end of the first settling stage. If needed, more ferric sulfate is added at this point.

6. Sodium hexametaphosphate is added for scale and corrosion control.

7. Ammonia is added as a disinfectant along with chlorine; it also makes the taste of the chlorine less noticeable.

8. Chlorine is added again.

Of the chemicals used, all of the carbon and ferric sulfate and nearly all of the lime settle out in the plant as sludge. Most of the pre-chlorine is consumed, a trace of the lime and the ammonia, post-chlorine, fluoride, and hexametaphosphate remain in the water going to the consumer. Figure 19 shows the plan and functions of a Dallas treatment plant.

TRANSMISSION AND DISTRIBUTION

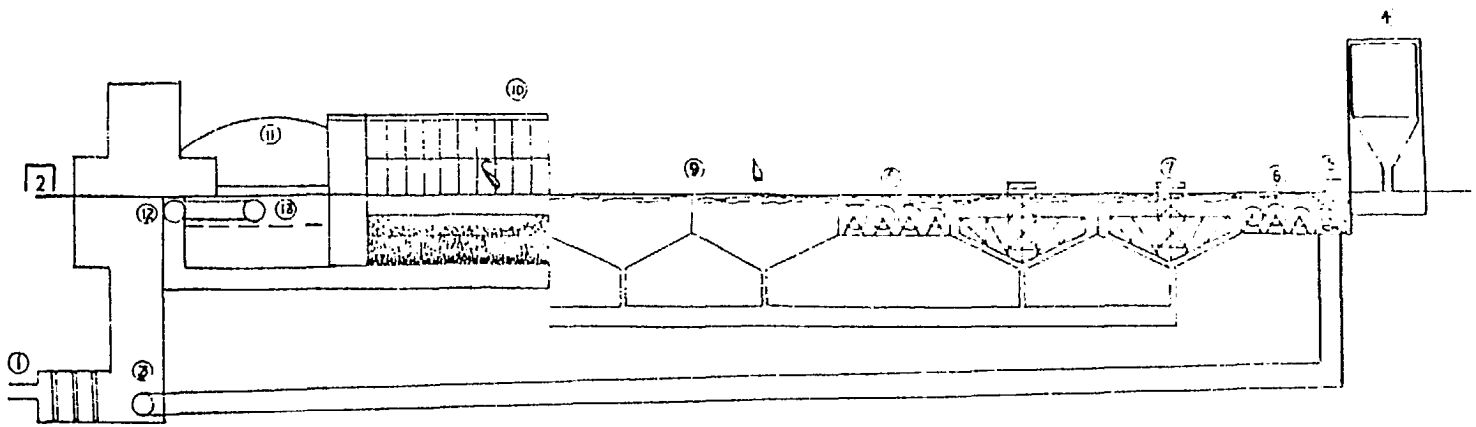
The distribution system consists of approximately 3,208 miles of mains composed of 2- to 90-in. pipe. To direct the flow of water to the proper areas and to control pressure, 32,000 valves have been installed. There are eight elevated tanks in the system to provide pressure together with 10.5 mil gal storage for peak demand periods. A difference of about 360 ft in elevation exists between the areas along the river channel and the surrounding hills.

The line from the East Side treatment plant to the Lake June reservoir is concrete pipe 90 in. in diameter. Transmission to the Southcliff reservoir is through a small line.

The Elm Fork plant pumps into a line to serve the city; it also serves the City of Irving through a 40-in. pipe, and Grand Prairie through a 36-in. line beyond Irving.

The Bachman plant pumps into three 36-in. lines that fan out over the central part of the city into the business district and on to South Dallas.

Within the distribution system, nine ground storage reservoirs have a total capacity of 141.87 mil gal. Each reservoir is paired with a high-pressure pump station to boost water into the distribution system under enough pressure to deliver it to the customer, The eight elevated storage tanks provide: 1) slack in the system so that the pumps are not pumping against a closed system and overheating, 2) an additional 10.5 mil gal storage. During peak consumption when it is impossible for booster pumps to deliver enough water to remote areas within the system, water is provided to these areas by gravity from the elevated tanks. Table 38 lists system storage facilities.



(1) Raw water conduits.

(2) Carbon storage for control of taste and odor.

(3) Raw water pumps - pump water to chemical building. Gravity flow from chemical building through plant to clear wells.

(4) Chemical building - where chlorine, lime, alum and ferric sulfate are added for purification and softening.

(5) Rapid mixers - chemicals and river water are mixed.

(6) Primary flocculators - chemicals are slowly mixed until chemical reactions take place.

(7) Primary settling tanks - chemicals and suspended matter settle out.

(8) Secondary flash mixers and flocculators - more chemicals may be added to increase clarification in final settling tanks, or control taste and odor.

(9) Secondary settling basin - final settling of treated water to remove most of the suspended solids.

(10) Filters - filtration through sand for removal of remaining suspended matter that will not settle. A small quantity of chlorine and ammonia is added after filtration to assure removal of all bacteria.

(11) Clear wells - to store treated purified water at the plant until needed.

(12) Filtered water pumps - to pump the treated water to distribution system.

(13) Supply main to Dallas.

Figure 19. Plan of a Dallas water treatment plant.

TABLE 38. DALLAS WATER UTILITY STORAGE FACILITIES

Type of storage	Ground elevation (ft)	Overflow elevation (ft)	Capacity* (mil gal)
Elevated storage tanks:			
Cedardale	586	702	0.5
Forest Lane	632	752	2
Garland Road	603	714	2
Plano Road	617	752	2
Red Bird	746	875	1
Trinity Heights	612	717	1
Western Hills	685	787	1
Western Hills (ground storage)	686	767	1
	Elevation bottom (ft)	Elevation top (ft)	Capacity (mil gal)
Ground storage reservoirs:			
Beltwood	623	643	10.0
Casa View	547	562	3.5
Greenville	608	627	21.6
Lake June	494	516	21.4
Southcliff	584	606	26.0
Sunset	608	627	15.9
Walcrest	626	648	20.1
Bachman+	429+	444	10.0
Elm Fork+	443+	459	13.3

* Total storage capacity is 152.3 mil gal.

+ Clear well

COST ANALYSIS

Growth in consumer demand for water from 1964 through 1974 is shown in Figure 20.

Using the standard cost categories defined earlier, data were collected and reported as shown in Tables 39, 40, and 41. As indicated by the relative increases in the support services category, a major portion of the operating budget was expended for labor. Table 42 examines the labor costs associated with operations and maintenance and gives the total payroll expended along with the total number of man-hours on payroll.

Table 42 shows that the cost/man-hour has increased over 10 years by 131%, whereas the total payroll hours required to produce 1 mil gal of RPW decreased by 22%. Thus the operating cost for producing water did not increase as rapidly as the labor cost/man-hour. When it is no longer possible to gain increasing efficiencies with respect to manpower, the payroll cost will start to increase at the same rate as the labor cost.

Table 43 summarizes operating and capital costs for the 10-year period of analysis and Table 44 lists capital and operating expense ratios. The operating expenses are costs incurred in normal day-to-day operations. Capital expenses are the total of the depreciated values of the periodic expenditures on major equipment items and facilities plus the interest charged on money borrowed for that purpose.

A comparison of the operating and capital expenses as a percent of the total cost shows that more expenses were associated with operations than with capital. Over the 10-year period, this trend continued primarily because of a continued increase in the cost of items associated with operations, such as salaries. Capital costs also increased slightly, but not at the same rate as operating expenses.

Because the Dallas system is relatively old, the capital depreciated was expended when costs were significantly lower. On the other hand, the operating expense is in current dollars. This ratio will change whenever capital investments are made by the utility. For example, major expenditures are planned for constructing new reservoirs and pipelines. When this occurs, the ratio of capital to operating expense will increase significantly.

SYSTEM COSTS

Examination of the costs on a functional basis is only part of the total cost picture. Since the purpose of a water supply utility is to deliver water to a consumer, it is important to be able to present costs in such a way that they relate to the delivery of water to a demand point within the utility's distribution system. The functional categories, both operating and capital, will therefore be reaggregated and assigned to physical components in the water delivery system.

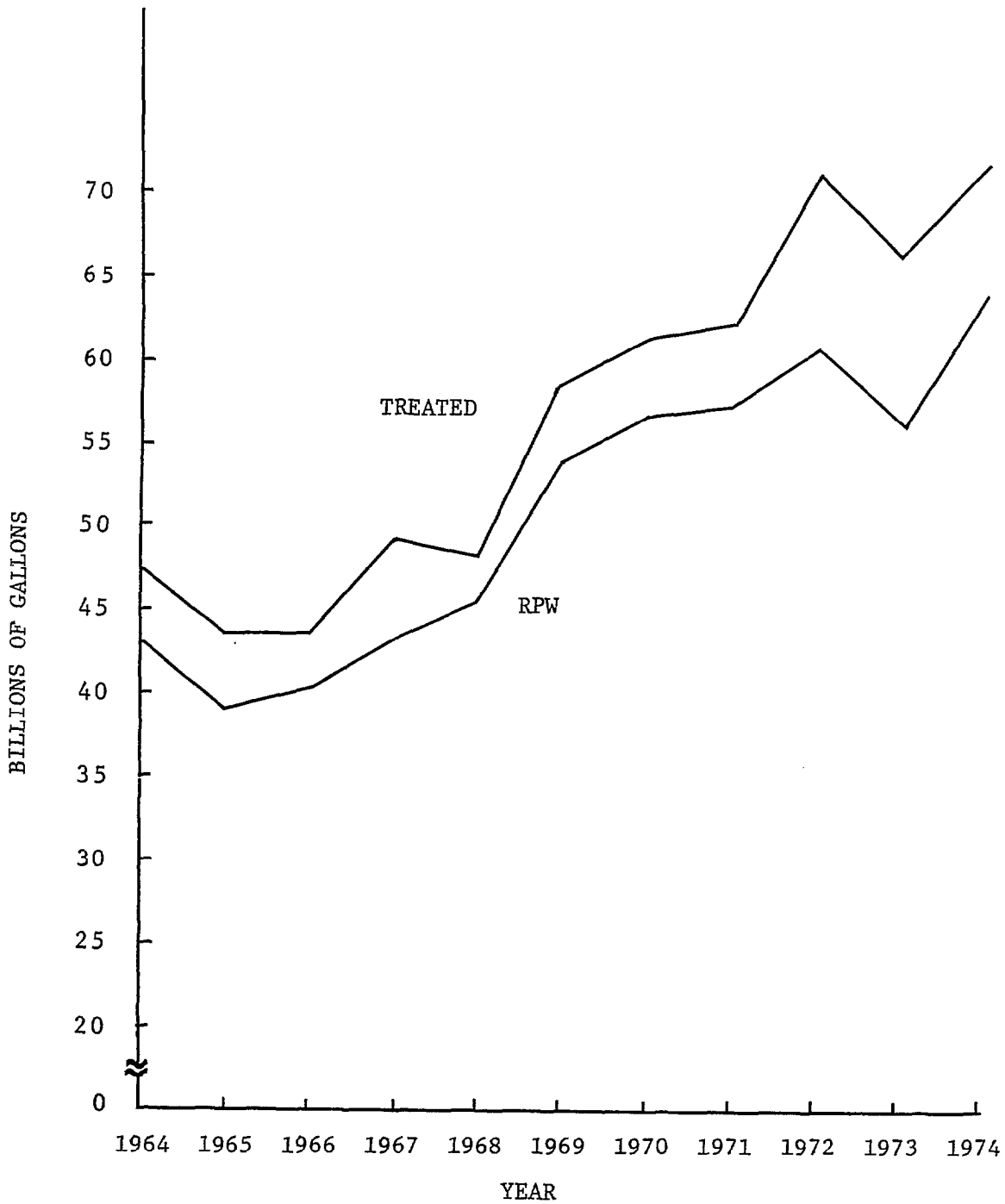


Figure 20. Dallas Water Utility water flow: treated water versus RPW.

TABLE 39. DALLAS WATER UTILITY ANNUAL OPERATING COSTS

Category	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
Support services:										
Administration	$ 530,135	$ 540,798	$ 616,410	$ 707,941	$ 957,709	$1,189,749	$1,320,763	$ 537,166	$ 677,837	$ 509,168
Acctg & collection	822,425	907,782	1,043,523	1,161,223	1,322,772	1,474,440	1,552,938	1,716,325	2,099,736	1,928,061
Other	2,610	2,329	4,054	3,675	4,811	5,993	618,498	1,510,872	1,624,958	2,263,210
Total overhead	1,355,170	1,450,909	1,663,987	1,872,839	2,285,292	2,670,182	3,492,199	3,764,363	4,402,531	4,700,439
Acquisition:	524,440	537,779	597,257	515,147	495,129	501,031	577,571	533,481	756,126	688,105
Treatment:										
Supervision and labor	556,380	577,366	573,028	655,615	766,745	879,388	1,032,354	1,079,892	1,166,396	1,240,568
Chemicals and supplies	693,419	706,144	729,556	723,275	838,152	836,382	888,443	907,206	1,009,252	1,151,276
Other	127,316	165,173	145,665	130,784	154,199	185,992	285,408	319,931	397,390	396,605
Total treatment	1,377,115	1,448,683	1,448,249	1,509,674	1,759,096	1,901,762	2,206,205	2,307,029	2,573,038	2,788,449
Power and pumping:										
Supervision and labor	454,234	454,181	515,622	562,015	636,310	676,597	802,553	933,639	928,523	849,759
Miscellaneous services	489,789	502,600	530,983	528,055	655,995	673,864	642,147	766,508	876,909	892,073
Other	55,148	45,978	47,600	52,817	43,349	53,842	76,134	81,006	102,275	64,421
Total power and pumping	999,171	1,002,759	1,094,205	1,142,887	1,335,654	1,404,303	1,520,834	1,781,153	1,907,707	1,806,253
Transmission and distribution:										
Supervision and labor	894,528	975,233	1,095,557	1,242,960	1,352,503	1,466,236	1,368,530	1,608,508	1,787,916	1,952,521
Maintenance	261,572	291,502	299,637	284,162	259,426	316,959	351,940	413,654	411,147	406,501
Miscellaneous services	188,285	212,094	210,432	214,990	253,241	266,819	276,539	325,031	431,043	54,309
Other	86,392	93,499	86,752	104,634	97,390	128,756	107,110	125,893	120,684	131,464
Total trans. & dist.	1,430,777	1,572,328	1,692,378	1,846,746	1,962,560	2,178,770	2,104,119	2,473,086	2,750,790	2,544,794
Total operating cost	5,686,673	6,012,458	6,496,076	6,887,293	7,837,731	8,656,048	9,900,928	10,859,112	12,390,192	12,528,040

TABLE 40. DALLAS WATER UTILITY UNIT OPERATING COSTS ($/MIL GAL RPW)

Category	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
Support services:										
Administration	$ 13.50	$ 13.72	$ 14.29	$ 15.60	$ 17.92	$ 21.07	$ 23.35	$ 8.85	$ 12.11	$ 8.08
Accounting and collection	20.94	23.04	24.19	25.59	24.75	26.11	27.46	28.28	37.50	30.59
Other	0.07	0.06	0.09	0.08	0.09	0.11	10.94	24.89	29.02	35.91
Total overhead	34.51	36.82	38.57	41.27	42.76	47.29	61.75	62.02	78.63	74.57
Acquisition:	13.35	13.65	13.85	11.35	9.26	8.87	10.21	8.79	13.50	10.92
Treatment:										
Supervision and labor	14.17	14.65	13.28	14.45	14.34	15.57	18.25	17.79	20.83	19.68
Chemicals and supplies	17.66	17.92	16.91	15.94	15.68	14.81	15.71	14.95	18.01	18.27
Other	3.24	4.19	3.38	2.88	2.88	3.29	5.05	5.27	7.10	6.29
Total treatment	35.07	36.76	33.57	33.27	32.90	33.67	39.01	38.01	45.95	44.24
Power and pumping:										
Supervision and labor	11.57	11.53	11.95	12.39	11.90	11.98	14.19	15.38	16.58	13.48
Power	12.47	12.76	12.31	11.64	12.27	11.93	11.35	12.63	15.66	14.15
Other	1.40	1.17	1.10	1.16	0.81	0.95	1.35	1.33	1.83	1.02
Total power and pumping	25.44	25.46	25.36	25.19	24.98	24.86	26.89	29.34	34.07	28.66
Transmission and distribution:										
Supervision and labor	22.78	24.75	25.40	27.39	25.30	25.96	24.20	26.50	31.93	30.98
Maintenance	6.66	7.40	6.95	6.26	4.85	5.61	6.22	6.81	7.34	6.45
Miscellaneous services	4.79	5.38	4.88	4.74	4.74	4.72	4.89	5.35	7.70	0.86
Other	2.20	2.37	2.01	2.31	1.82	2.28	1.89	2.07	2.16	2.09
Total transmission and distribution	36.43	39.90	39.24	40.70	36.71	38.57	37.20	40.73	49.13	40.37
Total operating cost	144.80	152.59	150.29	151.78	146.61	153.26	175.06	178.89	221.28	198.76

TABLE 41. DALLAS WATER UTILITY OPERATING COST CATEGORIES AS PERCENT OF TOTAL OPERATING COSTS

Category	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
Support services:										
Administration	9.32	8.99	9.49	10.28	12.22	13.75	13.34	4.95	5.47	4.07
Accounting and collection	14.46	15.10	16.06	16.86	16.88	17.04	15.69	15.81	16.95	15.39
Other	.05	.04	.06	.05	.06	.07	6.25	13.91	13.11	18.08
Total support services	23.83	24.13	25.61	27.19	29.16	30.86	35.28	34.67	35.33	37.54
Acquisition:	9.22	8.95	9.20	7.48	6.32	5.79	5.83	4.91	6.10	5.49
Treatment:										
Supervision and labor	9.79	9.60	8.82	9.52	9.78	10.16	10.42	9.94	9.41	9.90
Chemicals and supplies	12.20	11.74	11.23	10.50	10.70	9.66	8.97	8.36	8.14	9.19
Other	2.24	2.75	2.24	1.90	1.96	2.15	2.88	2.94	3.21	3.16
Total treatment	24.23	24.09	22.29	21.92	22.44	21.97	22.27	21.24	20.76	22.25
Power and pumping:										
Supervision	7.99	7.56	7.94	8.16	8.12	7.82	8.11	8.60	7.49	6.78
Power	8.61	8.36	8.17	7.67	8.37	7.78	6.48	7.06	7.08	7.12
Other	0.97	0.77	0.73	0.76	0.55	0.62	0.77	0.74	0.83	0.51
Total power and pumping	17.57	16.69	16.84	16.59	17.04	16.22	15.36	16.40	15.40	14.41
Transmission and distribution:										
Supervision and labor	15.73	16.22	16.87	18.05	17.26	16.94	13.82	14.81	14.43	15.59
Maintenance	4.60	4.85	4.61	4.12	3.31	3.66	3.55	3.81	3.32	3.25
Miscellaneous services	3.31	3.53	3.24	3.12	3.23	3.08	2.79	2.99	3.48	0.43
Other	1.52	1.55	1.33	1.52	1.24	1.49	1.08	1.16	0.97	1.05
Total transmission and distribution	25.16	26.15	26.05	26.81	25.04	25.17	21.24	22.77	22.20	20.32